Hoechst Celanese

Chemical Group
Hoechst Celanese Corporation
Bay City Plant
PO Box 509
Highway 3057
Bay City, TX 77404-0509

April 26, 1994
IOC-037-94

CERTIFIED MAIL

Mr. Ben K. Knape - Head
UIC Team
UIC, Uranium and Radioactive Waste Section
Industrial and Hazardous Waste Division
Texas Natural Resource Conservation Commission
P. O. Box 13087
1700 North Congress Avenue
Austin, Texas 78711-3087

Subject: **PRESSURE FALLOFF MECHANICAL INTEGRITY TESTING (MIT) AND FALLOFF REPORT FOR WDW-14**

Dear Mr. Knape:

Enclosed are two copies of the Pressure Falloff and MIT report for WDW-14 which are provided for your review and approval. As you are aware, the testing occurred between February 16th and February 22nd, 1994 and was performed by our Contractor, ECO Solutions, Inc., Houston, Texas.

Please don't hesitate to contact me at 409/241-4197 if you have comments and/or questions concerning the report.

Very truly yours,

I. O. Coleman, Jr. / cjs

I. O. Coleman, Jr.
Environmental Section Leader

IOC/cjs
attachment

cc: Mr. Laurence G. Walker, Geologist
UIC Team
Industrial and Hazardous Waste Division
Texas Natural Resource Conservation Commission
P. O. Box 13087
Austin, Texas 78711-3087

Mr. Phil Dellinger - **CERTIFIED MAIL** - w/report
Underground Injection Control Program
Environmental Protection Agency
1445 Ross Avenue, Suite #1200
Dallas, Texas 75202-2733

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MAY - 3 1994

Hoechst

ECO Solutions, Inc.

HOECHST CELANESE CHEMICAL GROUP, INC.
Bay City Plant

PRESSURE FALLOFF AND MECHANICAL INTEGRITY TESTING FOR WDW-14 (Well #2)

Prepared by:

ECO Solutions, Inc.
10333 Richmond, Suite 250
Houston, Texas 77042

March 1994

Job No. 94-004

TABLE OF CONTENTS

APPENDICES

1.0 INTRODUCTION AND EXECUTIVE SUMMARY

1.1 INTRODUCTION

Hoechst Celanese Chemical Group, Inc. (HCCG) contracted ECO Solutions, Inc. (ECO) to conduct bottom hole pressure falloff and mechanical integrity testing on WDW-14, HCCG's Class I injection well located at the Bay City, Texas facility. The attached report details the data and test results associated with that testing.

The following list provides an overview of the key elements of the testing:

* A bottom hole pressure (BHP) falloff test was conducted to satisfy the annual mechanical integrity test requirements of the U.S. Environmental Protection Agency (EPA) and the Texas Natural Resource Conservation Commission (TNRCC).

* An annulus pressure test was conducted to satisfy the annual mechanical integrity test requirements of the EPA and TNRCC.

* A differential temperature survey was recorded to satisfy that portion of the 5-year mechanical integrity test requirement of the TNRCC.

* A radioactive tracer survey was conducted to satisfy the annual requirements of the EPA and TNRCC.

The field operations were initiated on Wednesday, February 16th, 1994 and were completed on Tuesday, February 22nd, 1994. Mssrs. Reuben Alaniz and Robert Hall of ECO Solutions supervised the testing.

1.2 EXECUTIVE SUMMARY

WDW-14 was indefinitely taken out of service on February 22nd, 1994. The radioactive tracer survey conducted that day indicated a hole in the 9+5/8" protection casing 188' above the top of the permitted injection interval. Larry Walker of the TNRCC was on location while the survey was being conducted. The TNRCC and EPA, Region 6 were notified via telecommunications on February 23rd, and via written notification on February 25th (see Appendix J).

It should be noted that, with the exception of the hole in the casing, WDW-14 still has mechanical integrity in a conventional sense and is not an environmental risk. A review of the test and surveys conducted are listed below.

Radioactive Tracer Survey

The analysis of the radioactive tracer (RAT) survey demonstrated that no upward migration from the injection zone is occurring. However, the RAT did indicate a hole in the 9+5/8" protection casing at 3,168'. The hole is beneath the injection packer (see wellbore schematic) yet 188' above the top of the permitted injection interval at 3,350'.

The RAT survey indicated slight downward movement of fluids outside of the 9+5/8" protection casing from 3,168' - 3,212'. It does not appear that a significant amount of fluid has been injected out through the hole. This interpretation is also supported by the temperature survey that was conducted.

The RAT was witnessed by Mr. Larry Walker of the TNRCC and Robert Hall of ECO.

Differential Temperature Survey

The analysis of the differential temperature survey indicated no interformational transfer of fluids occurring behind the cemented protection casing from the top of the permitted interval back to the surface.

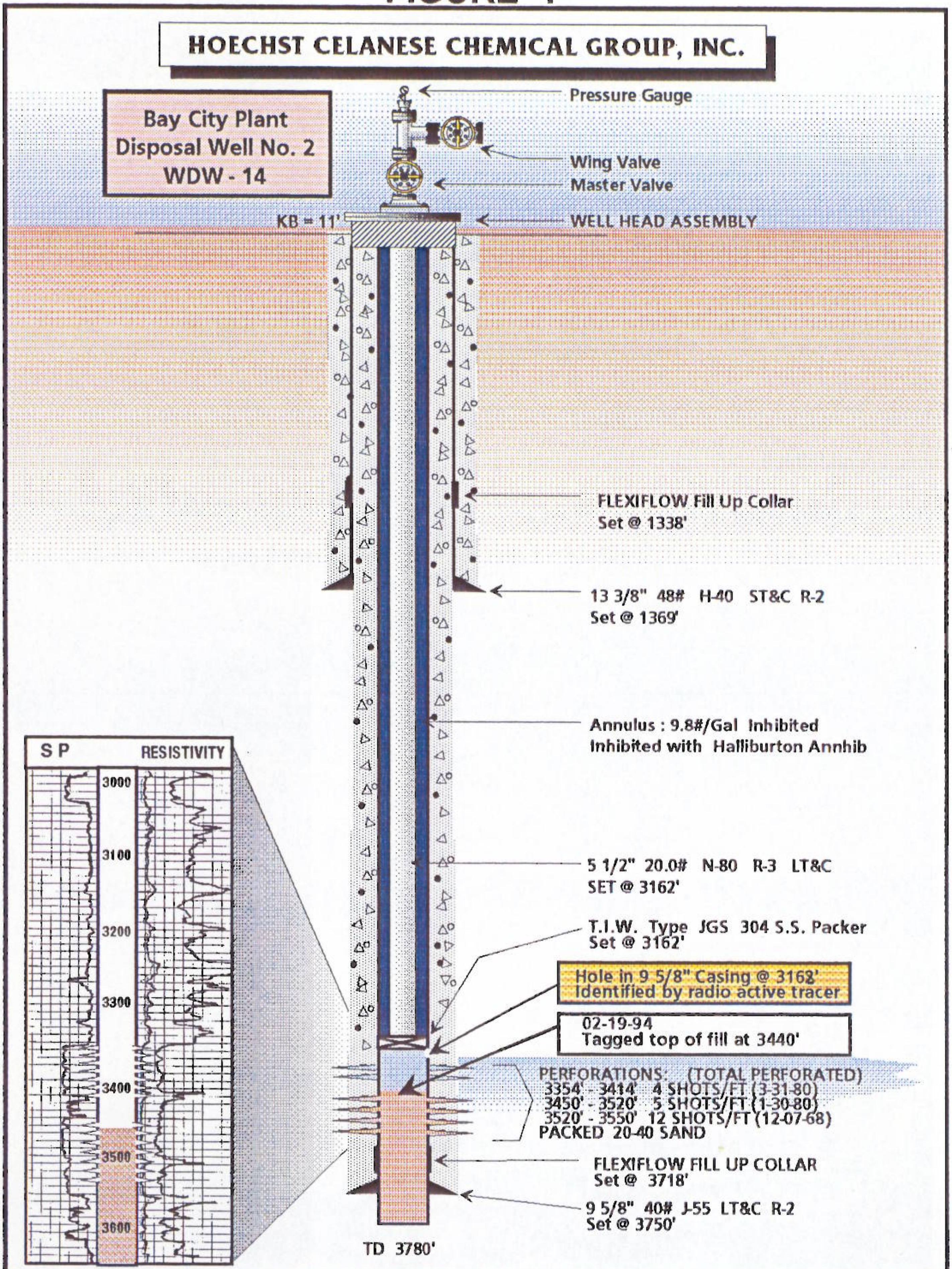
The differential temperature survey supports the RAT in regard to fluid movement through the hole. The differential temperature survey does not identify any thermal anomalies in the area of the hole in the protection casing at 3,168' that could be attributed to significant movements of fluid through the hole.

Annulus Pressure Test

A demonstration of a leak-free annulus was supported by an annulus pressure test (APT). The annulus was pressurized to 892.4 psig on February 21, 1994 for a one (1) hour test. The corresponding shut-in tubing pressure was 75.5 psig at the beginning of the test.

At the end of the test the annulus pressure had decreased to 886.6 psig with a corresponding shut-in tubing pressure of 75.8 psig. The total pressure loss of 5.8 psi is within the 5% pressure loss criteria set by the TNRCC.

FIGURE 1


HOECHST CELANESE CHEMICAL GROUP, INC.
Bay City Plant
Disposal Well No. 2
WDW - 14
Pressure Gauge
Wing Valve
Master Valve
KB = 11'
WELL HEAD ASSEMBLY
FLEXIFLOW Fill Up Collar
Set @ 1338'
13 3/8" 48# H-40 ST&C R-2
Set @ 1369'
Annulus : 9.8#/Gal Inhibited
Inhibited with Halliburton Annhib
5 1/2" 20.0# N-80 R-3 LT&C
SET @ 3162'
T.I.W. Type JGS 304 S.S. Packer
Set @ 3162'
Hole in 9 5/8" Casing @ 3162'
Identified by radio active tracer
02-19-94
Tagged top of fill at 3440'
PERFORATIONS: (TOTAL PERFORATED)
3354' - 3414' 4 SHOTS/FT (3-31-80)
3450' - 3520' 5 SHOTS/FT (1-30-80)
3520' - 3550' 12 SHOTS/FT (12-07-68)
PACKED 20-40 SAND
FLEXIFLOW FILL UP COLLAR
Set @ 3718'
9 5/8" 40# J-55 LT&C R-2
Set @ 3750'
TD 3780'
S P
RESISTIVITY
3000
3100
3200
3300
3400
3500
3600

HOECHST CELANESE CHEMICAL GROUP, INC. - WDW-14 (Well #2)

EVENT TIMELINE

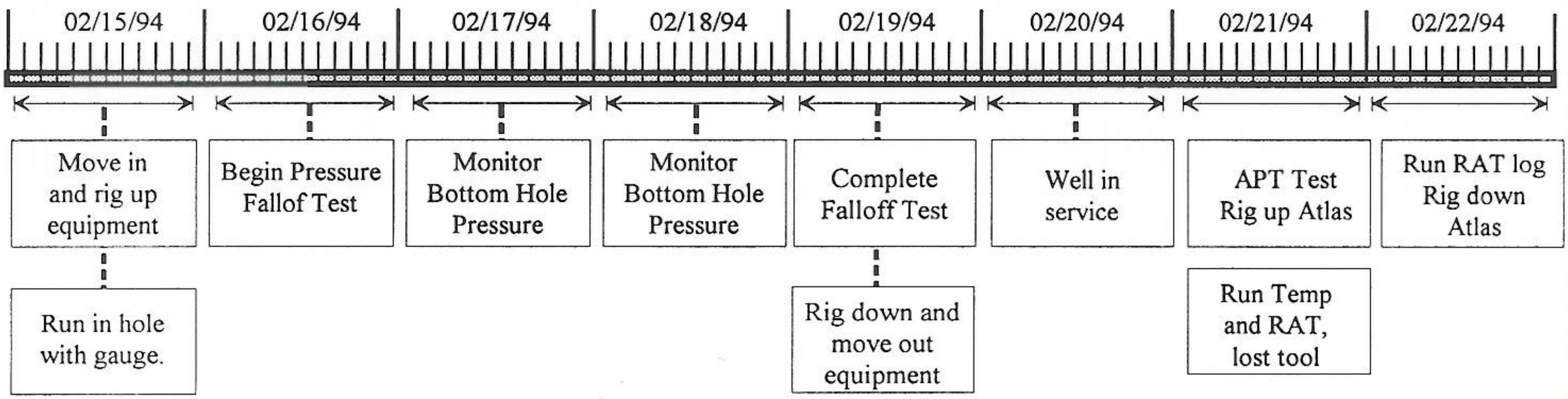


TABLE OF EVENTS

Feb. 15, 1994	Feb. 16, 1994	Feb. 17, 1994	Feb. 18, 1994	Feb. 19, 1994	Feb. 20, 1994	Feb. 21, 1994	Feb. 22, 1994
Move in and rig up equipment.	Begin Pressure Falloff Test.	Monitor Bottom Hole Pressure.	Monitor Bottom Hole Pressure.	Complete Falloff Test.	No field operations.	Perform Annulus pressure test.	Run RAT log.
Run in hole with Panex gauge.				Rig down and move out equipment.		Run Temp. log. Run RAT, lost tool in hole.	Rig down Atlas

FIGURE 2

ECO Solutions, Inc.
Houston, Texas

WDW-14TL.DRW / 3-29-94 / J# 94-007

2.0 SUMMARY OF FIELD OPERATIONS

Monday, February 14, 1994

A meeting was held with Ray Horton (Maintenance Engineer) to discuss and prepare for the fall-off test scheduled for February 16, 1994. Mr. Reuben Alaniz met with group leaders at the Utilities Department and discussed preparation for fall-off test. The subjects discussed were as follows:

- The shut-down of WDW-32 (Well #3) and WDW-110 (Well #1-A) prior to February 16.
- Shut-in points of Well #3 and Well 1-A, concerning pressure monitoring.
- Blind flange or slip flange injection line going into Well #2.
- Annulus Pressure test on Well #2 following fall-off.

Wednesday, February 16, 1994

Milton Cooke Wireline on location and began spotting equipment.

Reuben Alaniz met with Ray Horton and reviewed the proposed test procedures. Started rigging up on Well #2.

WDW-110 Well #1A	out of service	-	Monday, February 16, 1994.
WDW- 14 Well #2	maintain constant rate	-	Monday, February 16, 1994.
WDW- 32 Well #3	out of service	-	Monday, February 16, 1994.
WDW- 49 Well #4	out of service	-	July, 1993.

Begin GRC Data Acquisition System with GRC EPG-520 gauge (S/N 69491).

Pressured up lubricator with Surface Read Out and Memory Gauge back-up tool string. Adjusting wireline counter, prepared to go in hole.

Injection Rate WDW-14 (Well #2)	169 gpm
Surface Injection Pressure	480 psig
Surface Injection Temperature	92 Deg.F

Going in hole with well injecting.

Injection Rate	169 gpm
Surface Injection Pressure	485 psig

Gauge lowered to test depth of 3,440 feet. Begin monitoring bottom hole injection pressure and temperature. A plant operator blocked valve by mistake and a corresponding pressure decrease was observed. The valve position was immediately corrected.

Monitoring WDW-14 (Well #14) injection period.

Injection Rate	169 gpm
Down hole Injection Pressure	1789 psia @ 3,440'
Surface Injection Pressure	480 psig

Thursday, February 17, 1994

Continue monitoring WDW-14 injection period.

Injection Rate	170 gpm
Down hole Injection Pressure	1788 psia @ 3,440'
Surface Injection Pressure	480 psig

Generate Cartesian curve to evaluate pressure stability.

Continue monitoring injection period.

Injection Rate	170 gpm
Down hole Injection Pressure	1789 psig @ 3,440'
Surface Injection Pressure	480 psig

Generate Cartesian curve to evaluate pressure stability.

Friday, February 18, 1994

Continue monitoring WDW-14 injection period.

Injection Rate	169 gpm
Down hole Injection Pressure	1791 psia @ 3,440'
Surface Injection Pressure	485 psig

Generate Cartesian curve to evaluate pressure stability. Contact plant personal at Utilities control room to prepare for fall-off test.

Shut down Injection pump at Control room 1 and begin fall-off test.

Final Injection Rate	169 gpm
Final Down hole Injection Pressure	1790 psia @ 3,440'
Surface Injection Pressure	485 psig

Monitor fall-off period.

Down hole Shut-in Pressure	1580 psia @ 3,440'
Surface Shut-in Pressure	0 psig

Continue to monitor fall-off period.

Down hole Shut-in Pressure	1577 psia @ 3,440'
Surface Shut-in Pressure	78 psig

Generate semi-log and log-log curves for observation.

Saturday, February 19, 1994

Continue monitoring WDW-14 fall-off period.

Down hole Shut-in Pressure	1575 psia @ 3,440'
Surface Shut-in Pressure	74 psig

Generate semi-log and log-log curves for observation. Prepare to end fall-off test.

End of WDW-14 fall-off test.

Down hole Shut-in Pressure	1575 psia @ 3,440'
Surface Shut-in Pressure	74 psig

Move tool downhole to tag bottom. Tagged fill at 3,440 ft. Began pulling out of hole making static gradient stops.

Gauges at surface, end of static gradient survey. Bleed down lubricator and rig down wireline.

Sunday, February 20, 1994

Well in service. No field operations.

Monday, February 21, 1994

All contractors went through the HCCG orientation at Plant Protection and then again down at the well. Larry Walker of the TNRCC on location to witness mechanical integrity testing.

HCCG personnel pressurized the annulus to 892.4 psig on February 21, 1994 for a one (1) hour test. The corresponding shut-in tubing pressure was 75.5 psig at the beginning of the one (1) hour test. At the end of the test the annulus pressure had decreased to 886.6 psig with a corresponding shut-in tubing pressure of 75.8 psig. Pressure test successful.

Atlas Wireline Services was rigged up to run temperature and radioactive tracer survey. Unable to get 1+11/16" logging tools through upper portion of wellhead. HCCG personnel removed same and bored out welded area extending into the inner diameter of wellhead.

Atlas logged differential wellbore temperatures from surface down to the top of fill at 3,443'. Atlas ran the API gamma-ray base log tie in log and two (2) gamma-ray base logs. The logging tools became lodged in the perforated interval and were pulled off the electric line before the Atlas operator could react to the situation (see Appendix K for logging tools left in hole). Pulled out of the hole. Closed well in for night (CWIFN).

Tuesday, February 22, 1994

Western Atlas picked up additional logging tools this A.M. Atlas conducted the RAT as follows.

1. Ran API gamma-ray tie in strip.
2. Ran #1 base log from 3,348' to 2,776'.
3. Ran #2 base log from 3,348' to 2,776'.
4. Made multiple pass survey #1 with a radioactive slug ejected at 2,900' and a pump rate of 20 gpm.
5. Made multiple pass survey #2 with a radioactive slug ejected at 2,900' and a pump rate of 20 gpm.
6. Ran a stationary survey #1 at 3,342'. Watched slug pass tool and ran check for 15 minutes more. Pump rate was 50 gpm.
7. Ran a stationary survey #2 at 3,342'. Watched slug pass tool and ran check for 15 minutes more. Pump rate at 50 gpm.
8. Ran Gamma Ray base log after survey- repeated passes over "hot" spot at 3,168'.

"Hot" spot, apparent hole in protection casing, downward fluid movement indicated on log.

Pulled out of the hole and rigged down Western Atlas. Discussed same with Mr. Larry Walker of the TNRCC, decision made to close well in. CWIFN.

Wednesday, February 23, 1994

Tom Jones and Robert Hall of ECO met with HCCG personnel to discuss log analysis. Discussed same with Larry Walker of the TNRCC. Made additional notifications to TNRCC and USEPA Region 6 of HCCG's intent to take the well out of service for as yet an undefined time period.

Rigged down and released Western Atlas.

Thursday, March 3, 1994

Move in and rig up B & G pump truck. Brined in WDW-14, 120 bbls of 9.8 ppg brine inhibited with Halliburton Anhib. Rigged down and released B & G.

3.0 PRESSURE FALLOFF TESTING AND ANALYSIS

3.1 PRESSURE FALLOFF TESTING

Pressure falloff testing commenced on February 16, 1994 and concluded on February 19, 1994. The flowing bottomhole pressure was monitored for a total of 49.38 hours followed by a twenty-four (24) hours shut-in period. The period of last shut-in was October 23 - 26, 1993 and a graphic presentation of injection versus days for this 115 day period is included as Figure 3. Plots and data for the test are included in Appendices A and B, respectively.

3.2 PRESSURE FALLOFF ANALYSIS

Method Of Interpretation: The following analysis was performed by utilizing both Semi-Log and Log-Log analysis. A) The *Semi-Log* curve was generated by plotting pressure vs the superposition time function utilizing the given rate history. The semi-log straight line was then calculated by linear regression through the infinite acting flow period of the falloff curve. The semi-log slope and P_{1hr} values were obtained from the semi-log straight line and utilized for the final permeability and skin calculations. B) The *Log-Log* curves were generated by plotting Delta-P/Delta-Q and Pressure derivative vs the Agarwal Equivalent time function. The Log-Log curves were simultaneously positioned over $[T_D/C_D]$ wellbore storage type-curves until a solution match was obtained. Permeability and skin values were calculated from this match and then compared with those obtained from the Semi-Log analysis.

A. *Semi-Log (Superposition)*: The straight line area of the semi-log curve was identified by first using the 1-1/2 log cycle rule to estimate the end of wellbore storage effects. Secondly, the time of the flat portion from the pressure derivative curve was used in determining the area of the semi-log curve in which the straight line was drawn. The semi-log straight line yielded a slope value of 5.0024 psi/cycle and a P_{1hr} of 1582 psi. The pressure difference between P_{1hr} and the injection pressure followed with the calculated slope would give indications of positive skin damage and high permeability.

B. *Log-Log ($[T_D/C_D]$ Wellbore storage Type-curves)*: The high maximum of the derivative curve illustrates wellbore storage and positive skin effects. The flattening portion of the derivative indicating the infinite acting flow period of the curve was observed approximately 1.8 hours following the start time of the falloff period. The flat portion of the derivative curve was the main factor used to obtain a type curve match yielding similar results to the semi-log analysis.

Conclusions: The system was diagnosed as a homogeneous reservoir with a calculated permeability of 1335 (md) and skin damage of +40.6 utilizing an h_{net} value of 210 feet. The flow efficiency of 21.5% suggests that the near wellbore conditions has large affects on the injection volume limitations and that the total pressure drop is primarily due to conditions within a small radius from the well.

The Following Table is provided to give comparative results with the previous test. The primary variables affecting the calculated results are included.

Date MM/YY	Rate GPM	h_{net} feet	Uw cp	Slope psi/cyl	kh/u md-ft	k md	S -
10/92	197	210	0.71	6.2000	177940	601.6	+ 23.7
02/94	169	210	1.49	5.0024	188184	1335.2	+ 40.6

The calculated results indicate a difference in transmissibility, (kh/u) of 5.4% and a difference in skin of 41.6% between the two tests. The increase in skin is most likely caused by the covering of the two bottom set of perforations (3450' - 3520' and 3520' - 3550'). The difference in the permeability values is due to the different viscosity values used in the calculations. The time to exit the waste front exceeded the start time of the infinite acting flow period, therefore the viscosity of the injection fluid was used for the analysis resulting in a much higher permeability value. However the transmissibility values are consistent between the two tests.

A homogeneous simulator was utilized to confirm the calculated results mentioned above. The main assumptions were as follows: a single well with infinite acting and radial flow conditions being injected at a constant rate with constant reservoir conditions such as porosity, permeability, and compressibility. Based on this particular reservoir the simulated data matched the actual data with a reasonable degree of accuracy.

The program used for final analysis and well simulation was "PanSystem 2.1", marketed by Edinburgh Petroleum Services. Plots of the analysis using the "PanSystem 21" are included as Figures 4 - 8.

Table 3.1
Falloff Test Data - WDW-14 (Well #2)

1.	*General Test Information*	
	Date of Test	February 16 - 19, 1994
	Time since stabilized pressure (hrs.)	2721
	Cumulative injection (gals.)	2402.35×10^6 gallons
	Wellbore radius (ft.)	0.45
	Gross completed interval (ft.)	160'
	Type of completion	Perforated
	Depth to fill	3,440'
	Justified interval thickness (ft.)	210'
	Average historical waste fluid viscosity (cps)	1.49
	Formation fluid viscosity (cps)	0.71
	Porosity (%)	33
	Total compressibility (psi^{-1})	5.0×10^{-6}
	Formation volume factor	1.0
	Initial formation bottomhole pressure (psia)	1501 (1968) @ 3,300'
2.	*Injection Period*	
	Time of injection period (hrs.)	49.38
	Injection rate (gallons per minute)	169
	Test fluid	Waste Fluid
	Pumps used for test	P61 Byron Jackson - Centrifugal
	Injection fluid viscosity (cps)	1.49
	Final injection pressure (psia)	1790.27
	Final injection temperature (°F)	106.47
	Gauge type	GRC EPG-520 Serial # 69491
	Gauge resolution and calibration	0.01
	Gauge depth (feet)	3,440

3.	*Falloff Period*	
	Total Shut-in Time (hrs.)	24.42
	Final Shut-in Pressure (psia)	1574.65
	Final Shut-in Temperature °F	106.79
	Final Shut-in Tubing Pressure (psia)	89

Table 3.2
Results of Analysis of Pressure Falloff Test
WDW-14 (Well #2)

	Semi-Log Superposition	Log-Log Type Curve	Semi-Log Synthesis
kh/μ (md-ft/cp)	188,184	188,154	188,154
Flow capacity (md-ft)	280,394	280,350	280,350
Permeability (mds)	1335.93	1335.0	1335.0
Skin effect	40.58	41.0	40.6
Dimensionless storage coefficient			Cs = 0.108
p* (psia)	1564.32		

3.3 COMPARISON TO PETITION MODEL DATA

The reservoir properties (pressure, permeability, etc.) of the upper Miocene injection interval were determined through falloff testing conducted on WDW-14. The flowing or operational formation pressures from the tests can be compared with the modeled operational pressures by converting the measured pressures to a depth of 3440' below ground level and removing the pressure increase due to skin effect. The formation pressures predicted by the model assume no formation damage effects or other near-bore conditions. The measured flowing pressures corrected for skin effects and maximum predicted operational pressures are presented in the Table below:

Formation Pressures WDW-14

Well Name	Flowing Formation Pressures, psi	Skin Pressure Loss, psi	Revised Formation Pressure, psi	Maximum Modeled Pressure, psi
WDW-14 (well 2)	1789	176	1613	1641

The measured flowing pressure is below the maximum modeled operational pressure by more than 28 psi for WDW-14. A graph of the modeled pressures for WDW-14 is included. The graph shows the yearly predicted modeled injection rates (250 gpm for each well). All predicted operational pressures correspond to a depth of 3440' below ground level and an original estimated formation pressure for the upper Miocene injection interval of 1555 psi.

The measured static formation pressures from the well tests, corrected to a depth of 3440' below ground level, show a formation pressure increase of 19 psi. This illustrates that injection operations at the plant have had limited impact on formation pressures and should continue to have limited impact on formation pressures in the future.

Static Formation Pressures From WDW-14 Well Test

Well Name	Static Formation Pressure at 3440'	Formation Pressure Increase, psi
WDW-14 (Well 2)	1574	+19

A comparison of the test permeability and transmissivity values with the modeled values of permeability and transmissivity for WDW-14 are given below:

Well Name	Test Permeability, mds	Petition Permeability, mds	Test Transmissivity, md-ft/cp	Petition Transmissivity, mf-ft/cp
WDW-14 (well 2)	1335	1350	188,184	313,700

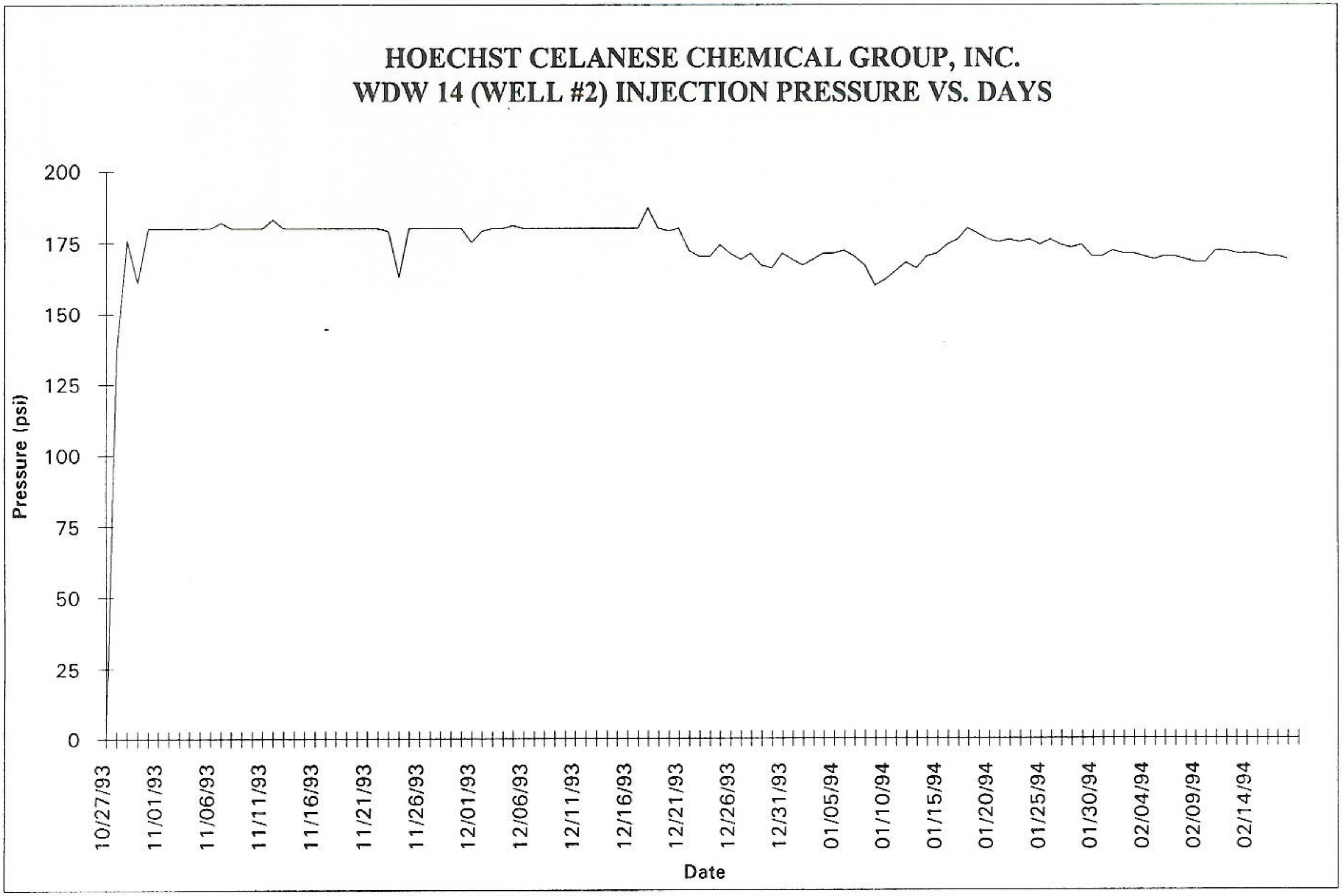
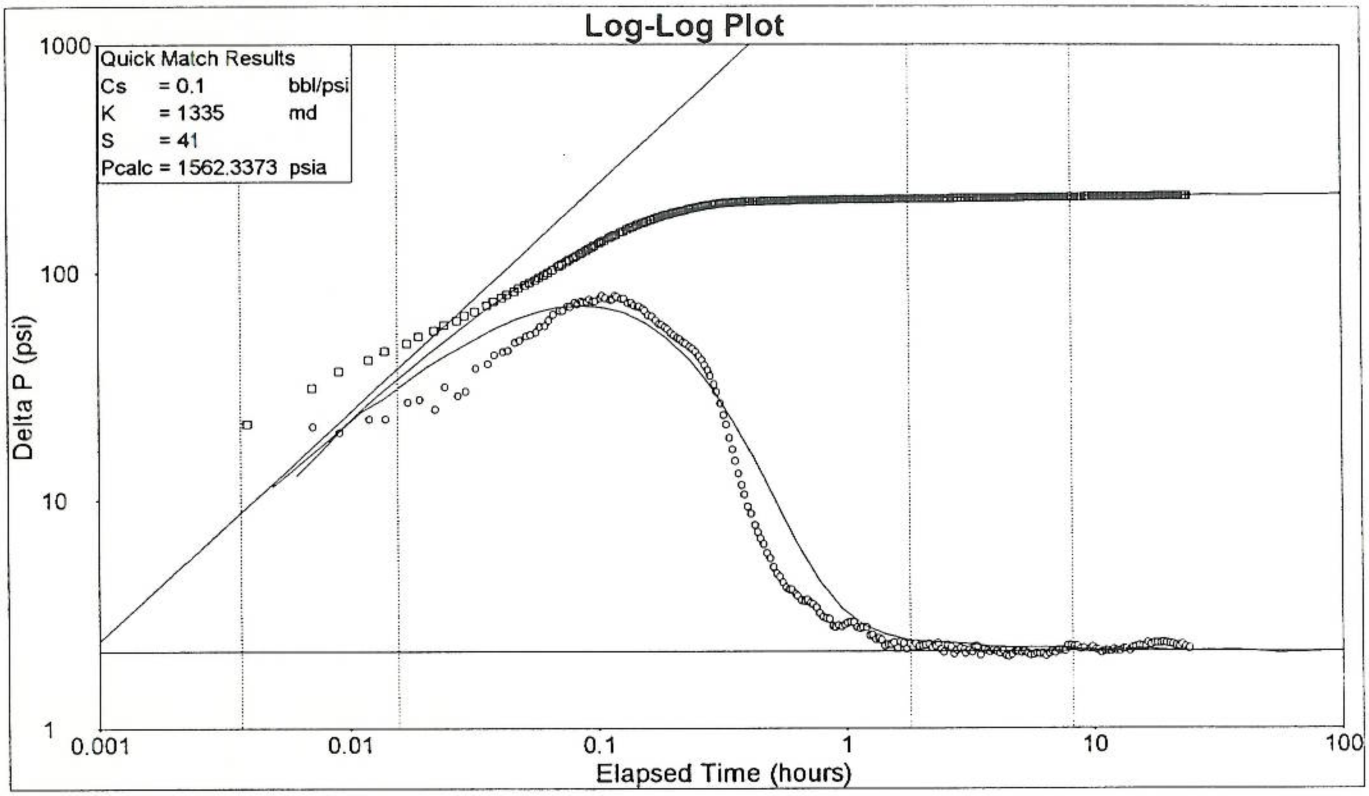


FIGURE 3

ECO SOLUTIONS, INC.

ECO Solutions, Inc.	Report File:	WDW14#2.PAN
MECHANICAL INTEGRITY TEST	Analysis Date:	4/04/94
Fall-Off Test Analysis		



HOECHST CELANESE
CHEMICAL GROUP, INC.
WDW-14 Well #2
Bay City Facility, Texas

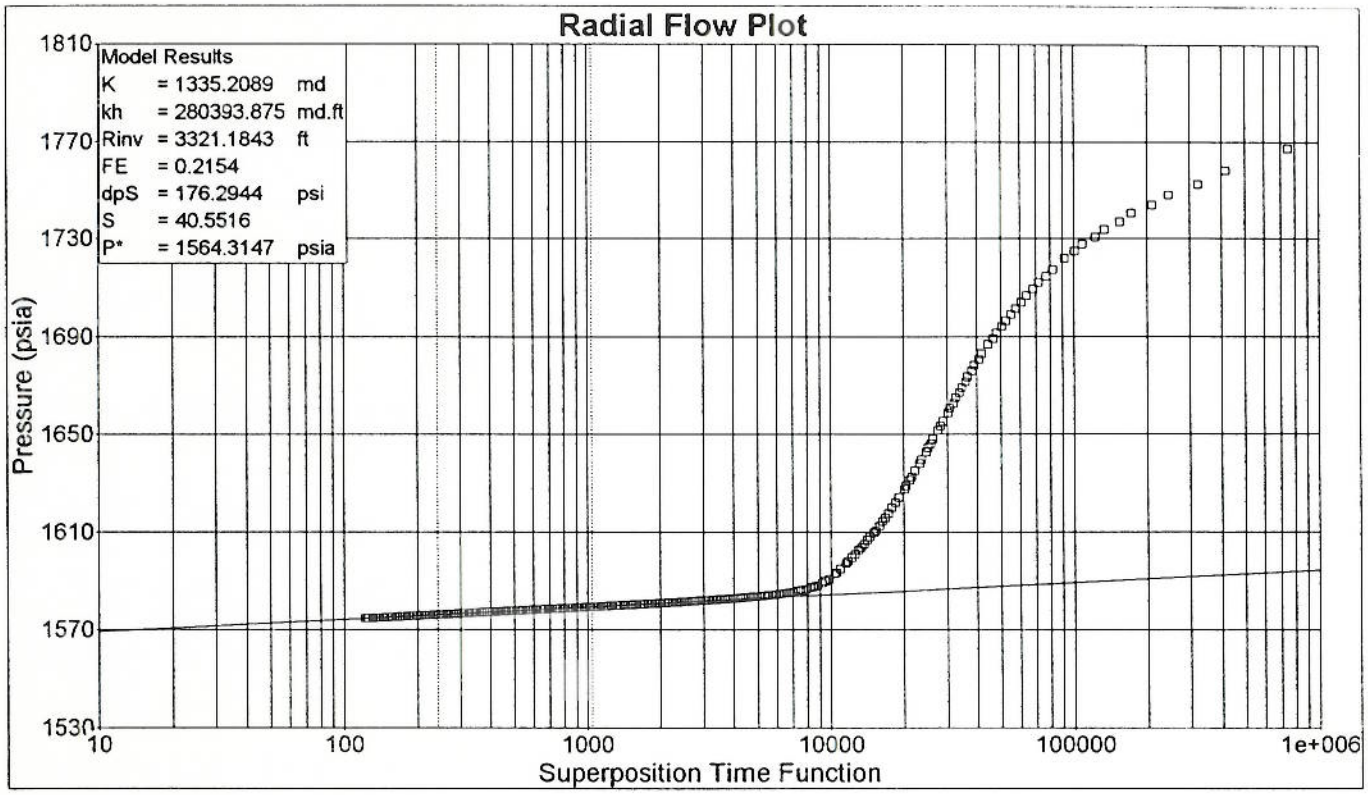
02/16-19/1994

Log-Log plot used to identify flow regimes.

End of unit slope:	Approximately 0.015	hours
Start of infinite acting flow period:	Approximately 1.8	hours
Time to exit waste front:	Approximately 2.6	hours

FIGURE 4

ECO Solutions, Inc.	Report File:	WDW14#2.PAN
MECHANICAL INTEGRITY TEST	Analysis Date:	4/04/94
Fall-Off Test Analysis		



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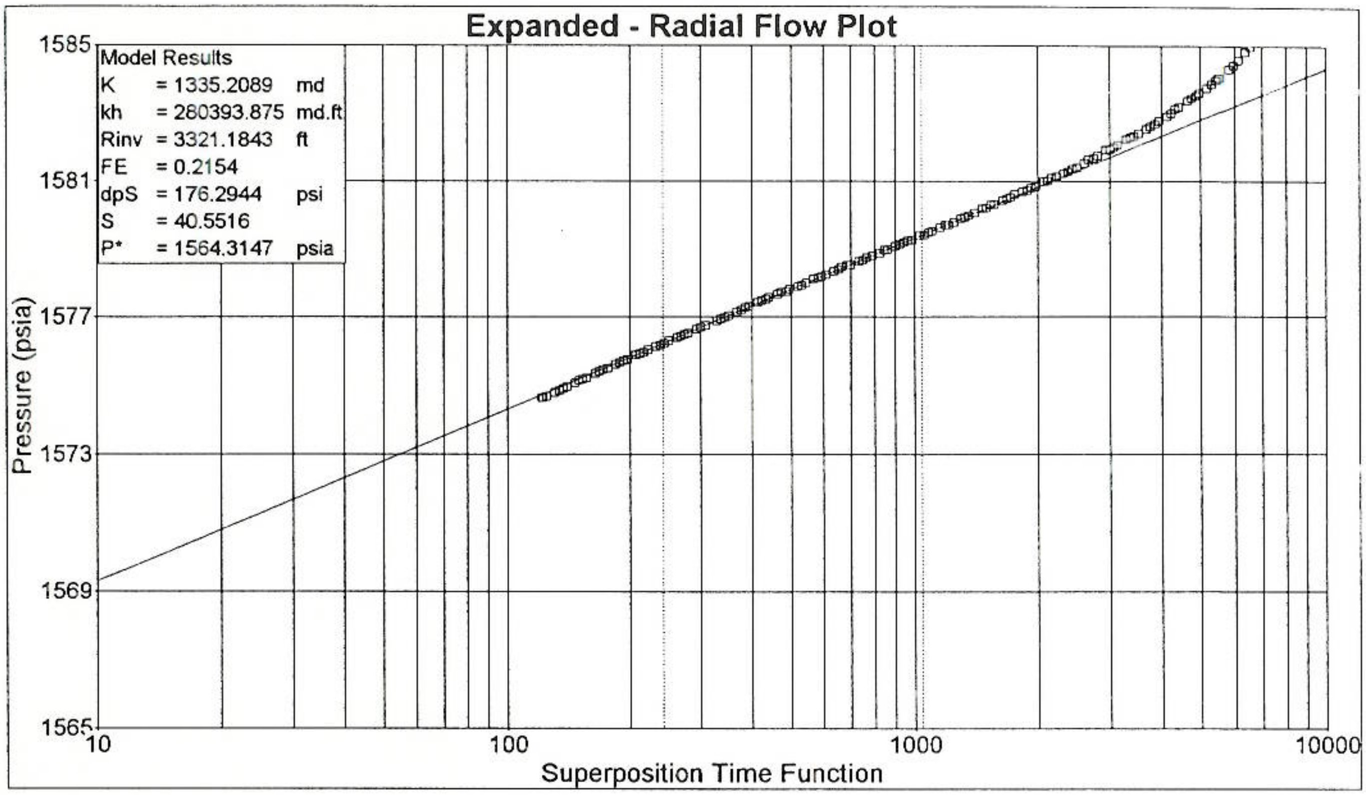
CHEMICAL GROUP, INC.
WDW-14 Well #2
Bay City Facility, Texas

02/16 - 19/1994

Semi-Log analysis utilizing Superposition Time Function.

FIGURE 5

ECO Solutions, Inc.	Report File:	WDW14#2.PAN
MECHANICAL INTEGRITY TEST	Analysis Date:	4/04/94
Fall-Off Test Analysis		



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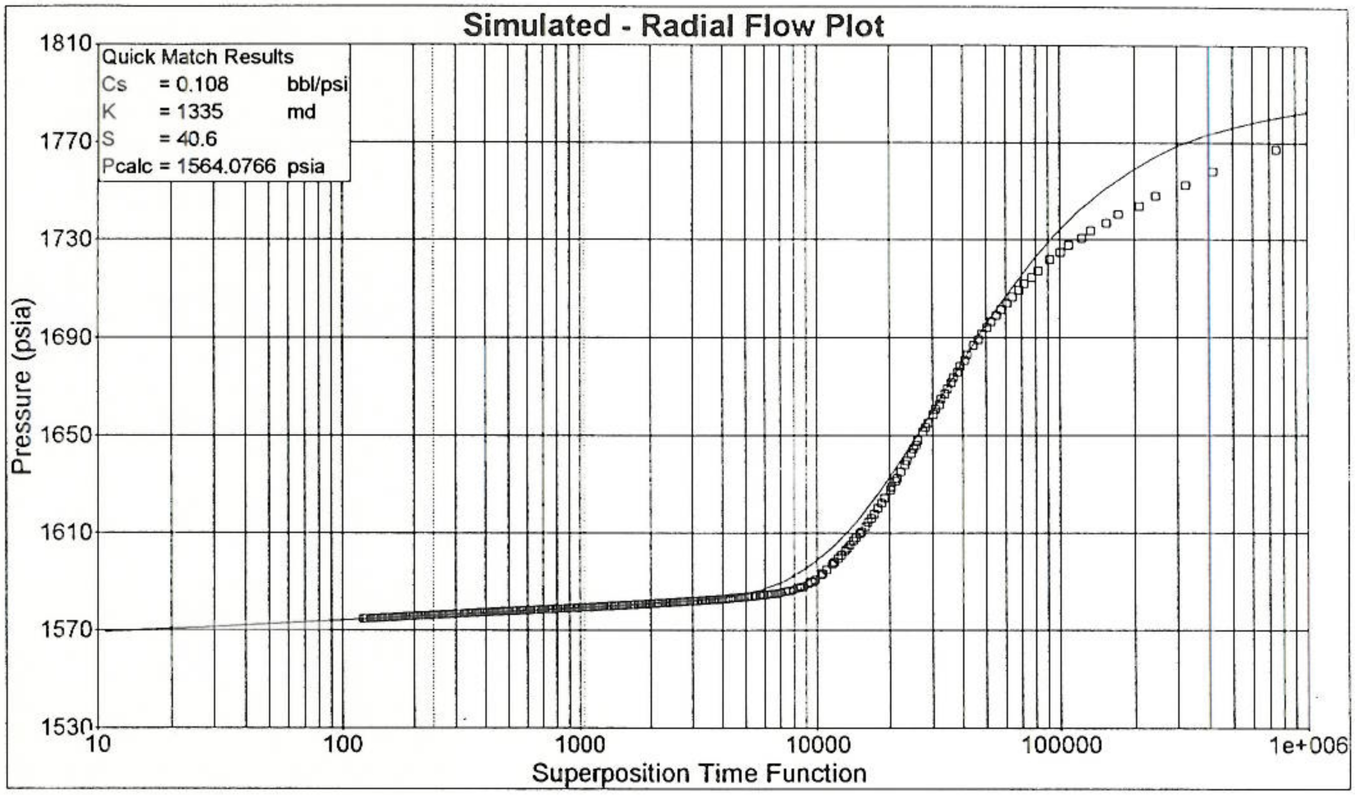
CHEMICAL GROUP, INC.
WDW-14 Well #2
Bay City Facility, Texas

02/16 - 19/1994

Semi-Log analysis utilizing Superposition Time Function.

FIGURE 6

ECO Solutions, Inc.		Report File:	WDW14#2.PAN
MECHANICAL INTEGRITY TEST		Analysis Date:	4/04/94
Fall-Off Test Analysis			



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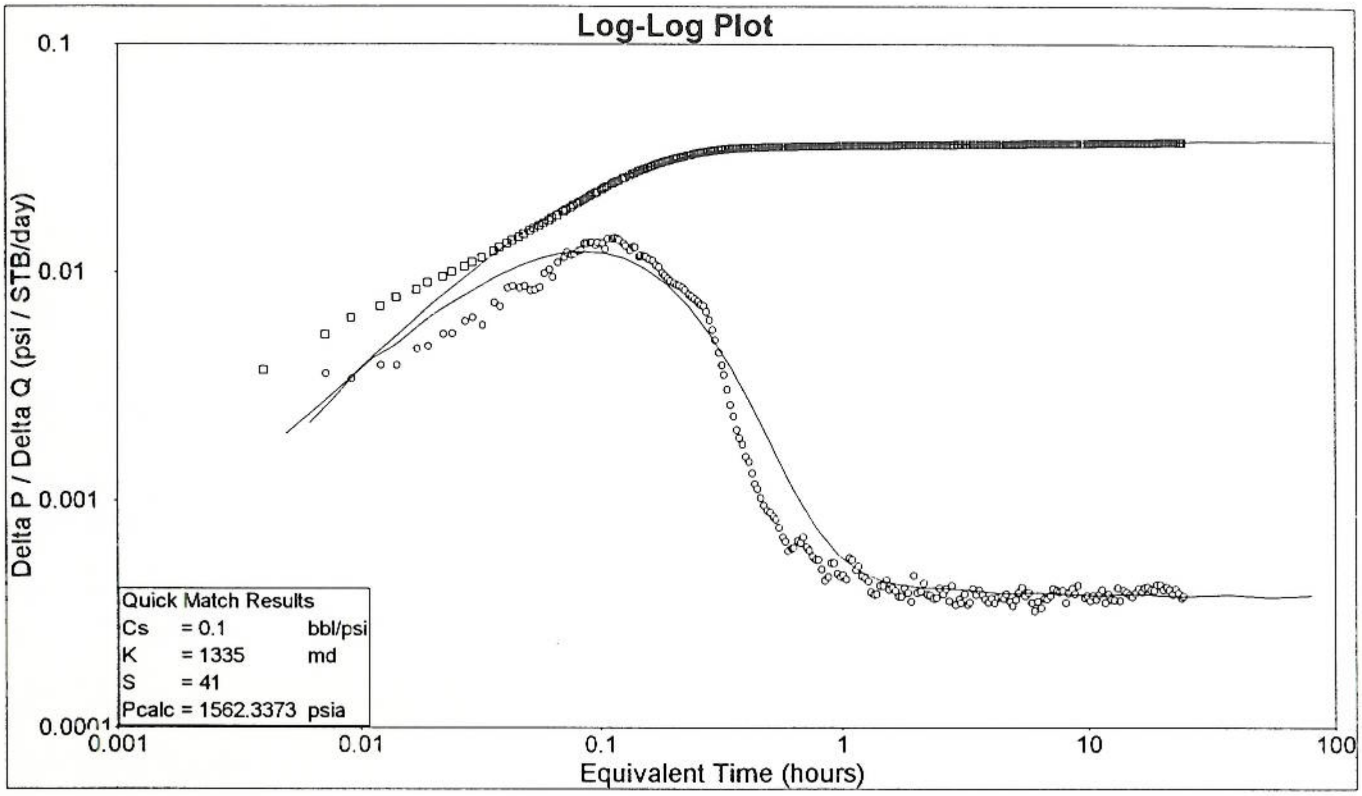
CHEMICAL GROUP, INC.
WDW-14 Well #2
Bay City Facility, Texas

02/16 - 19/1994

Semi-Log analysis utilizing Superposition Time Function.

FIGURE 7

ECO Solutions, Inc.	Report File:	WDW14#2.PAN
MECHANICAL INTEGRITY TEST	Analysis Date:	4/04/94
Fall-Off Test Analysis		



HOECHST CELANESE
CHEMICAL GROUP, INC.
WDW-14 Well #2
Bay City Facility, Texas

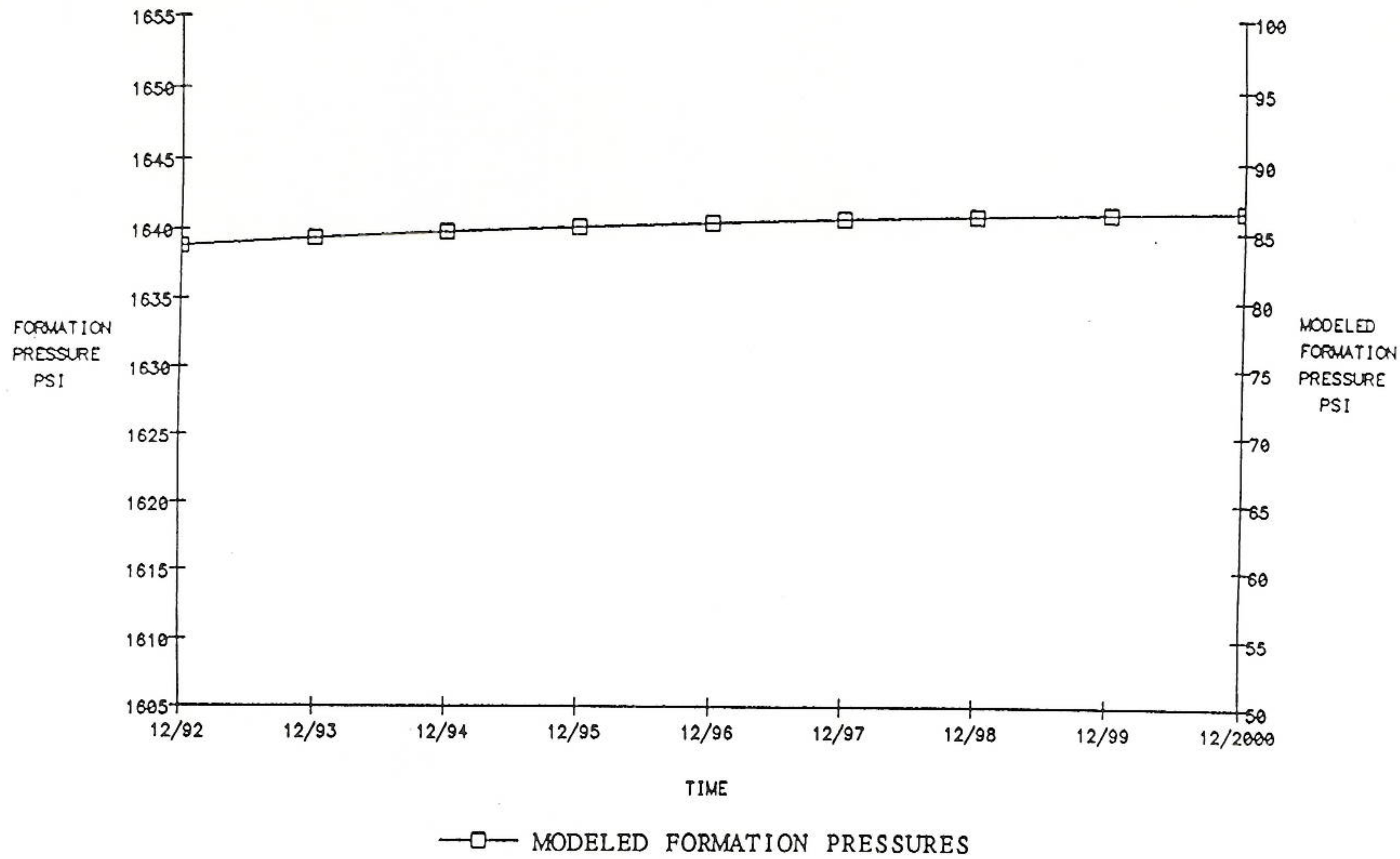
02/16-19/1994

Log-Log analysis utilizing Equivalent time function.

FIGURE 8

FIGURE 9

UPPER MIOCENE INJECTION SAND - WDW-14



MODELED OPERATIONAL FORMATION PRESSURES IN WDW-14 (1992 - 2000)

4.0 EVALUATION OF RADIOACTIVE TRACER SURVEY INJECTION WELL NO. 2 WDW-14

LOG DATA

Date Run:	February 22, 1994
Logging Service Company	Western Atlas International
Tubing Size and Depth Set	5 1/2" @ 3162'
Casing Size and Depth:	9 5/8" set @ 3650

BASELINE GAMMA-RAY LOG

This baseline gamma-ray log was run from 3348' to 2800'. The purpose of the initial baseline G/R log is to demonstrate repeatability of the logging tools. A comparison of both baseline G/R runs shows good repeatability between the two runs. A gamma ray spike is clearly seen at 3170' which is immediately below the packer. The tracer material was previously ejected from a malfunctioning tool which was subsequently replaced. As is discussed later, the hot spot is determined from additional logging runs to be a casing leak.

BEFORE SURVEY BASELINE GAMMA-RAY LOG 2

A baseline gamma-ray (G/R) was run from 3348' to 2776' to provide a repeat section used in a calibration check. The log is also useful for the following comparisons against additional RAT logging runs.

1. The G/R curves are used as depth control points against other runs during the RAT.
2. The baseline G/R is compared against the final G/R log to check for anomaly areas that could indicate upward migration along a cement channel.

The hot spot beneath the packer at 3170' is again clearly evident.

CHASE SURVEY 1

The multiple passes or chase survey portion of the RAT provides a check for fluid movement. In this instance, one slug was ejected at a depth of 2900' and it was tracked as it was pumped down the tubing. The pumping rate for this test was 20 gpm and eleven (11) individual passes (files 17 through 24) were made with two detectors as the slug moved from 2900' to 3046'. Both curves are illustrated on the multiple passes portion of the log. The relatively low flow rate of 20 gpm was necessary to allow sufficient time for the logging tools to be lowered to *make multiple passes and record the progress of the radioactive slug. A flow rate higher than 20 gpm would have caused the slug to move so fast that only a few passes could be made resulting in incomplete coverage of the movement. A summary of the individual passes is given below:*

a. Pass 1 *(file 17)* The slug was released at 2900' and the logging tool lowered below the tracer material and logged upward. The slug was recorded inside the tubing with its primary peak at 2962'. The logging pass is from 2998' up to 2888'.

b. Pass 2 *(file 18)* - The slug was recorded inside the tubing with its peak at 3080'. The slug has moved downward 118' since pass 1. The radioactive slug has spread out slightly by the passes of the logging tool. This is seen by the shape of the G/R response. The peak intensity is lower than pass 1 and the base of the curve is wider.

c. Pass 3 *(file 19)* - The slug was recorded in the 9 5/8" protection casing immediately below the packer which is seen on the casing collar log at 3160'. Twin peaks are observed. The main peak is at 3182' and a smaller one is at 3158'. The main slug has moved downward 102' since pass 2 and 220' since pass 1. The smaller peak observed in the baseline runs appears to have increased in intensity but remained at the same depth. The preliminary indication is a hole in the 9 5/8" casing with no apparent movement. The radioactive slug has spread out slightly by the passes of the logging tool.

d. Pass 4 *(file 20)* - The main slug continues to move downward with its peak at 3214'. The slug has moved downward 32' since pass 3 and 252' since pass 1. In the larger casing diameter, the fluid movement is slower. The secondary peak is unchanged and recorded at 3168'.

e. Pass 5 *(file 21)* - The slug was recorded in the 9 5/8" long string casing (below the packer) with its peak at 3248'. The slug has moved downward 34' since pass 4 and 286' since pass 1. The slug shape appears more compacted due to the lower velocity in the larger diameter. No upward migration is indicated on the secondary peak or hot spot at 3168'.

f. Pass 6 *(file 22)* - The main body of the radioactive slug is in the 9 5/8" casing. The slug was recorded with its peak at 3281'. The slug has moved downward 33' since pass 5 and 319' since pass 1. The secondary peak is not observed on this pass since the run was completed at a deeper depth.

g. Pass 7 *(file 23)* - The main body of the radioactive slug is in the 9 5/8" casing. The slug was recorded with its peak at 3314'. The slug has moved downward 33' since pass 6 and 352' since pass 1. The radioactive slug has spread slightly and its intensity diminished since it is being injected. The secondary peak is not observed on this pass since the run was completed at a deeper depth.

h. Pass 8 *(file 24)* - The main body of the radioactive slug is in the 9 5/8" casing. The slug was recorded with its peak at 3344'. The slug has moved downward 30' since pass 7 and 382' since pass 1. No upward migration is noted. The slug is passing downward past the tool as it is injected. The peak is much smaller in amplitude.

i. Pass 9 *(file 25)* - No distinctive peak is observed although the residual of the tracer slug is still observable. A majority of the tracer material has been injected and no upward fluid movement from the injection interval is indicated. The secondary peak is not observed on this pass since the run was completed at a deeper depth.

j. Pass 10 *(file 26)* - No distinctive peak is observed although a small residual of the tracer slug is still observable. The log reading is near the original baseline. A majority of the tracer material has been injected and no upward fluid movement from the injection interval is indicated. The secondary peak is not observed on this pass since the run was completed at a deeper depth.

k. Pass 11 *(file 27)* - This is a final pass from 3048' up past the packer to a depth of 3082'. A baseline reading is recorded with the exception of the hot spot at 3068'. No movement in the anomaly area is indicated.

CHASE SURVEY 2

The second multiple passes or chase survey portion of the RAT provides a redundant check for fluid movement and verifies the findings from the first chase survey. In this instance, one slug was ejected at a depth of 2900' and it was tracked as it was pumped down the tubing. The pumping rate for this test was 20 gpm and nine (9) individual passes (files 28 through 36) were made with two detectors as the slug moved from 2900' to 3046'. Both curves are illustrated on the multiple passes portion of the log. The flow rate of 20 gpm is used which is identical to chase survey no. 1. A summary of the individual passes is given below:

a. Pass 1A *(file 28)* - The slug was released at 2900' and the tool lowered below the tracer material and logged upward. The slug was recorded inside the tubing with its primary peak at 2971'. The logging pass is from 3000' up to 2900'.

b. Pass 2A *(file 29)* - The slug was recorded inside the tubing above the packer which is at 3160'. The slug peak is at 3120'. The slug has moved downward 149' since pass 1A. The radioactive slug has spread out which created a loss in amplitude. This shape is normal and is seen by the shape of the G/R response. In other words, the peak intensity is lower than pass 1A and the base of the curve is wider.

c. Pass 3A *(file 30)* - The slug was recorded in the 9 5/8" protection casing below the packer which is seen on the casing collar log at 3160'. As in chase survey 1, twin peaks are observed. The slug peak is at 3211'. The main slug has moved downward 91' since pass 2A and 240' since pass 1A. The smaller peak observed above the main slug body appears to have increased in intensity but remained at the same depth of 3167'. The preliminary indication is a hole in the 9 5/8" casing with no apparent fluid movement. The lower radioactive slug has spread out slightly by the passes of the logging tool.

d. Pass 4A *(file 31)* - The main body of the radioactive slug is in the 9 5/8" casing. The slug was recorded with its peak at 3261'. The slug has moved downward 104' since pass 3A and 344' since pass 1A. The secondary peak is not observed on this pass since the run was completed at a deeper depth. With the exception of the anomaly at 3167', no additional slug separation is observed.

e. Pass 5A *(file 32)* -The main body of the radioactive slug is in the 9 5/8" casing. The slug was recorded with its peak at 3300'. The slug has moved downward 39' since pass 4A and 383' since pass 1A. No upward migration is noted. The slug is passing downward past the tool as it is injected. The peak is much smaller in amplitude.

f. Pass 6A *(file 33)* - No sharp peak is observed although the tracer slug is still easily observable. Much of the tracer material has been injected and no upward fluid movement from the injection interval is indicated. The secondary peak is not observed on this pass since the run was completed at a deeper depth

g. Pass 7A & 8A *(files 34 & 35)* - No distinctive peak is observed although a small residual of the tracer slug is still observable. The log reading on pass 8A (file 35) is near the original baseline. A majority of the tracer material has been injected and no upward fluid movement from the injection interval is indicated. The secondary peak is not observed on this pass since the run was completed at a deeper depth.

j. <u>Pass 9A</u> *(file 36)* - This is a final pass from 3050' up past the packer to a depth of 3116'. A baseline reading is recorded with the exception of the hot spot at 3068'. No movement in the anomaly area is indicated.

FIRST STATIONARY READING ON TIME DRIVE

The stationary survey checks for upward migration under a high flow rate condition. In this case, a radioactive slug was released above 3342' and the recording done on a time drive basis. Fluid was pumped into the well at 50 gallons per minute (gpm) while recording the background radioactivity at a stationary point (3342') for 30 minutes. Since the slug was released above the detector, its passage is indicated on the log. Pumping is continued for the remainder of the 30 minute period while recording. No second G/R peak was detected and as such no upward migration from the injection interval was detected.

SECOND STATIONARY READING ON TIME DRIVE

This pass is identical to the previous pass but serves as a double check of the equipment and the presence of upward migration. The flow rate and tool position are the same as the previous pass.

A radioactive slug was released at 3342' and the recording done on a time drive basis. Fluid is pumped into the well at 50 gallons per minute (gpm) while recording the background radioactivity at a stationary point (3342') for 30 minutes. Since the slug is released above the detector, its passage is indicated on the log. Pumping is continued for the remainder of the 30 minute period while recording. No second G/R peak was detected and as such no upward migration from the injection interval was detected.

AFTER SURVEY BASELINE GAMMA-RAY LOG

Immediately after the secondary stationary survey, the logging tool was lowered to 3350'. An after survey baseline G/R log was recorded (file 41). The purpose of this log is to compare it with the before survey baseline G/R log to look for anomaly areas. These areas would appear as "hot spots" or areas in which the G/R readings have been elevated above background levels. A comparison between the before and after baseline G/R logs indicates the following:

1. The spike indicated at 3168' is residual tracer indicating a hole in the casing at that depth.

2. Two additional peaks not previously observed are indicated below the anomaly at 3168'. One is at 3179' and the other is at 3189'. The interpretation is that fluid movement downward occurred from the casing hole at 3168' in response to the increase in flow rate from 20 gpm to 50 gpm for the stationary surveys.

SECOND AFTER SURVEY BASELINE GAMMA-RAY LOG

A second baseline survey (file 42) was run to further record the downward movement observed from the anomaly area at 3168'. A comparison between the first and second after baseline G/R logs indicates the following:

1. The spike indicated at 3168' allowing fluid to exit the casing and move downward.

2. The two additional peaks not previously observed appear to be moving downward although the initial anomaly at 3168' has not moved.

MULTIPLE AFTER SURVEY BASELINE GAMMA-RAY LOG PASSES

Six additional baseline survey (files 43-48) were run to further record the downward movement observed from the anomaly area at 3168'. The overall result was to :

1. They supported the previous logging passes that there is a hole in the 9 5/8" casing at 3168' allowing fluid to exit the casing.

2. Fluid movement downward from 3168' is occurring.

4.1 RADIOACTIVE TRACER SURVEY CONCLUSIONS

1. A hole in the 9 5/8" casing is indicated at 3168' which is located immediately below the packer.

2. A small volume of fluid is exiting the casing at 3168' with the majority being injected through the perforations.

3. Fluid movement is indicated in a downward direction from 3168', however it does not extend to the top of the injection interval.

4. No upward fluid movement is observed from the casing leak at 3168' nor from the injection interval.

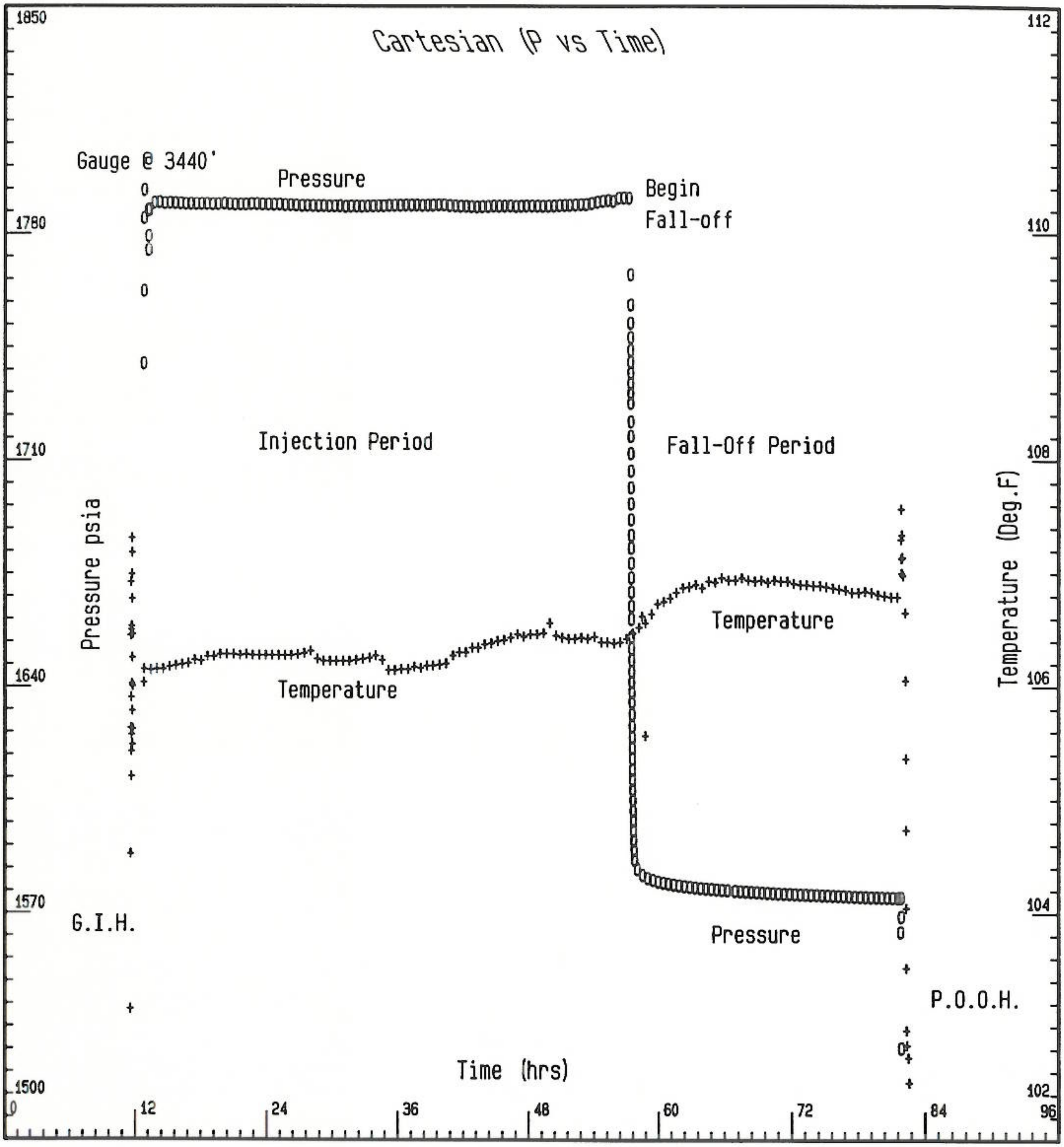
5. Fluid movement into the casing hole at 3168' was not observed at the lower flow rate of 20 gpm. Only when the flow rate was increased to 50 gpm was downward fluid movement initiated.

6. Since no anomaly in the area surrounding 3168' was observed on the temperature log, it is concluded that significant volumes of fluid have not entered the casing hole.

ECO Solutions, Inc.
Hoechst Celanese Chemical Group, Inc.
Pressure Falloff/MIT Testing

APPENDIX A

GENERAL FALLOFF PLOTS



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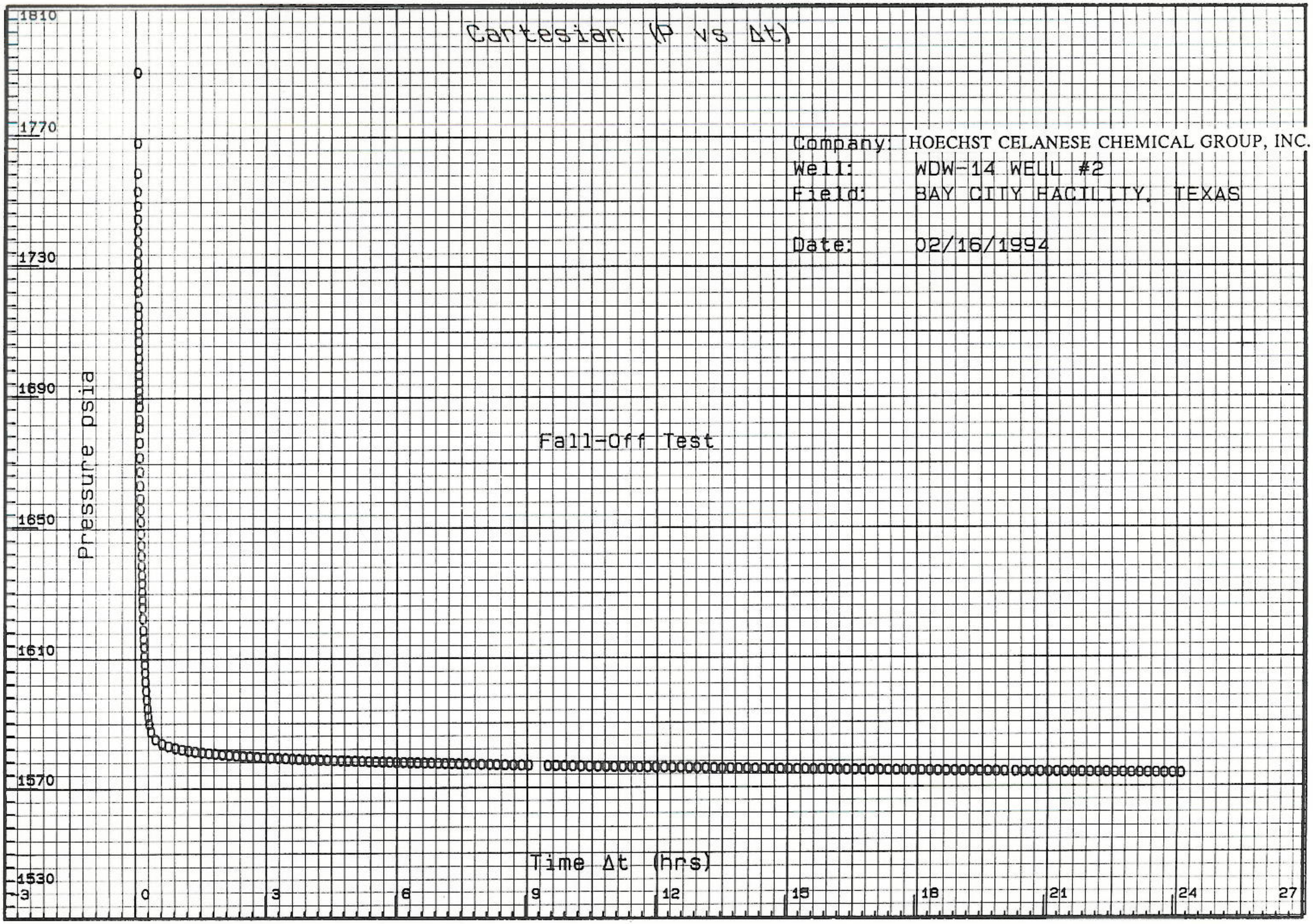
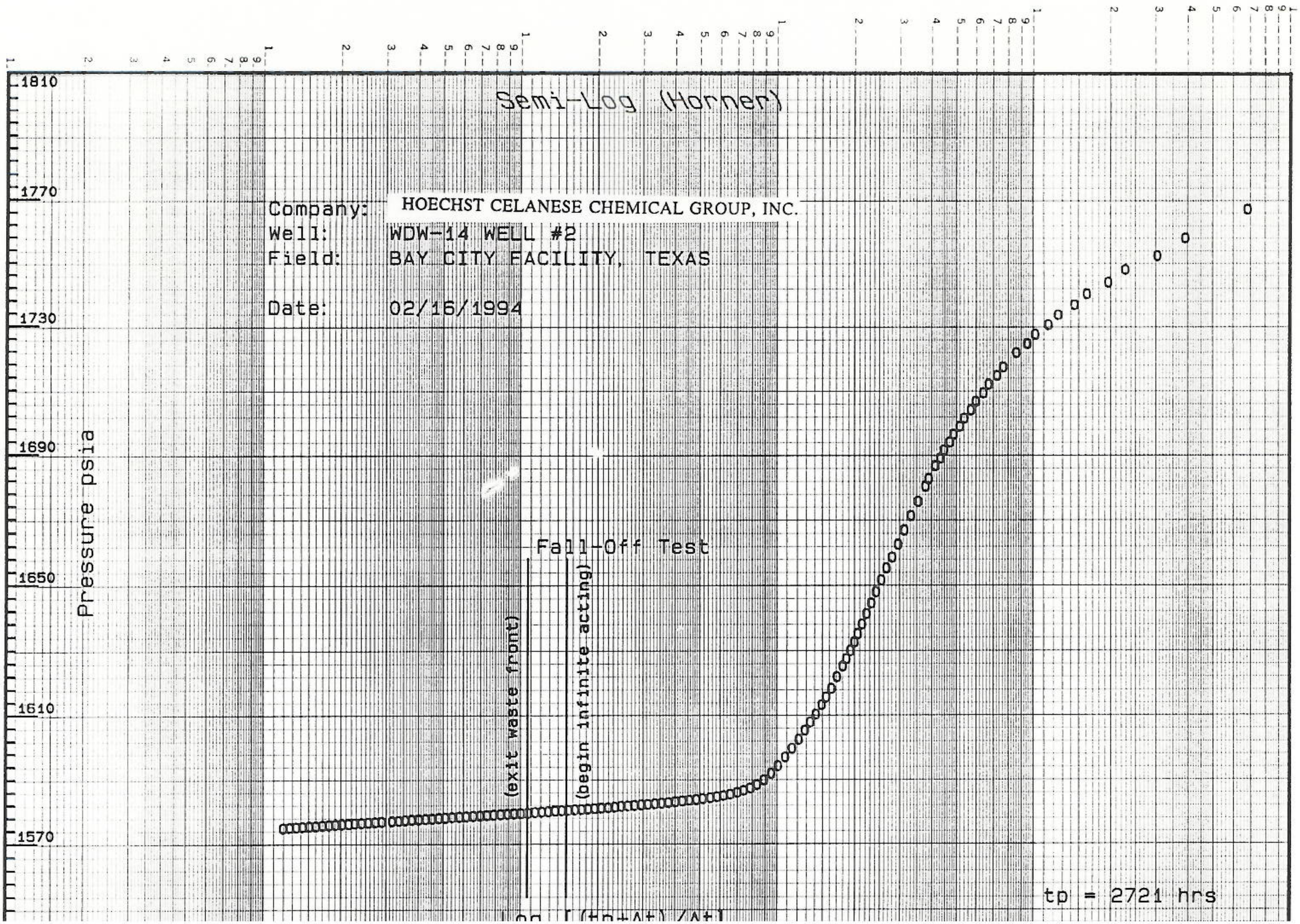
Well:	WDW-14 WELL #2	End Time:	11:34:12 02/19/1994
Field:	BAY CITY FACILITY, TEXAS		
Date:	02/16/1994		

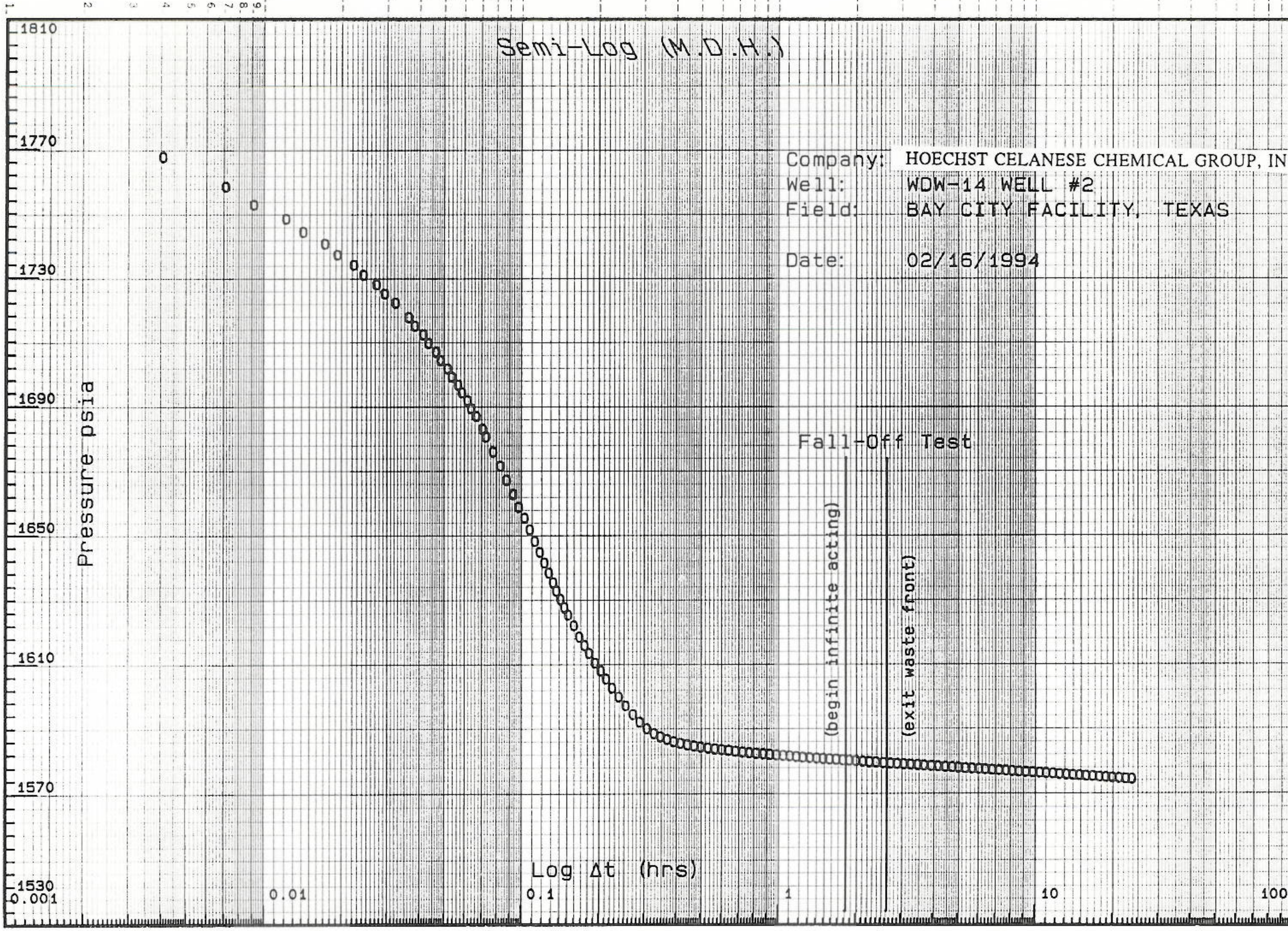
Injection Pressure = 1790 psi
Shut-in Pressure = 1575 psi
Injection Rate = 169 GPM


Cartesian (P vs Δt)
Company: HOECHST CELANESE CHEMICAL GROUP, INC.
Well: WDW-14 WELL #2
Field: BAY CITY FACILITY, TEXAS
Date: 02/16/1994
Fall-Off Test
Pressure psia
1810
1770
1730
1690
1650
1610
1570
1530
Time Δt (hrs)
-3
0
3
6
9
12
15
18
21
24
27

K+E SEMI-LOGARITHMIC 5 CYCLES X 70 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.

46 6210




Semi-Log (M.D.H.)
Company: HOECHST CELANESE CHEMICAL GROUP, INC.
Well: WDW-14 WELL #2
Field: BAY CITY FACILITY, TEXAS
Date: 02/16/1994
Fall-Off Test
(begin infinite acting)
(exit waste front)
Pressure psia
Log Δt (hrs)
1810
1770
1730
1690
1650
1610
1570
1530
0.001
0.01
0.1
1
10
100

K&E LOGARITHMIC 3 x 5 CYCLES
KEUFFEL & ESSER CO. MADE IN U.S.A.

46 7520